Defense Technical Information Center Compilation Part Notice

ADP012276

TITLE: Improvement of Crystallographic Characteristics of CoCrTa Thin Film Using Double Underlayer

DISTRIBUTION: Approved for public release, distribution unlimited

This paper is part of the following report:

TITLE: Applications of Ferromagnetic and Optical Materials, Storage and Magnetoelectronics: Symposia Held in San Francisco, California, U.S.A. on April 16-20, 2001

To order the complete compilation report, use: ADA402512

The component part is provided here to allow users access to individually authored sections of proceedings, annals, symposia, etc. However, the component should be considered within the context of the overall compilation report and not as a stand-alone technical report.

The following component part numbers comprise the compilation report:
ADP012260 thru ADP012329

Mat. Res. Soc. Symp. Proc. Vol. 674 © 2001 Materials Research Society

Improvement of crystallographic characteristics of CoCrTa thin film using double underlayer

Y.J.Kim*, S.H.Kong, S.Nakagawa**, M.Naoe** and K.H.Kim***
*School of Electrical & Electronic Eng., Kyungwon Univ., Kyunggi-do 461-701, Korea
**Dept. of Physical Electronics, Tokyo Institute of Technology, Tokyo 152-8522, Japan

ABSTRACT

High c-axis oriented CoCr-based thin films are expected for ultra-high density recording media in perpendicular magnetic recording system. In order to improve dispersion angle of c-axis of CoCr-based for perpendicular magnetic recording media, we prepared trilayered film with double underlayer using New Facing Targets Sputtering apparatus. The thickness of magnetic layer CoCrTa and double underlayer, such as interlayer Pt, paramagnetic CoCr, underlayer Ti was fixed 50nm and 20nm respectively. In order to prepare the thin film, we fixed argon gas pressure 1mTorr, substrate temperature 250°C and input current 0.5A. The crystallographic characteristics of CoCrTa layer with varying interlayer thickness (0- 20nm) have been investigated. By the result, the CoCrTa trilayered thin film with interlayer Pt showed good c-axis orientation 3.45° and 3.62° at thickness 5nm and 10nm respectively. However, CoCrTa thin film using interlayer paramagnetic CoCr showed 8.28° and 8.62° at thickness 5nm and 10nm respectively.

INTRODUCTION

Perpendicular magnetic recording [1] is regarded as a candidate for achieving ultra-high density above 100Gbits/in^2 [2]. Among the rest thin films of Co-Cr alloy with thickness of several tens of nanometers are known as most compatible media due to easiness of thin film preparation, and control of coercivity and saturation magnetization. In these thin film media of Co-Cr alloy the most important things are realization of being low-noise and high recording density. To overcome these, it is necessary to be thinner the thickness of ferromagnetic recording layer, and necessary to be finer grains. However, because of the formatted initial layer that exhibited to bad perpendicular characteristics, it should be improve magnetic characteristic of magnetic layer and be thinner the initial layer as much as a possible [3]. In this study, the effects of inserting interlayer to CoCrTa/Ti doublelayer media for perpendicular magnetic recording are observed.

EXPERIMENTAL DETAILS

Films were prepared by using the New Facing Targets Sputtering apparatus with box type sputtering units. FTS [4,5] was in which substrate was located apart from plasma, so called

plasma free, and could restrain bombardment to substrate from γ-electron and negative ion as high-energy particles and maintain the stable electrical discharge at low gas pressure. Forming the magnetron mode with varying location of a permanent magnet, NFTS [6] can confine plasma effectively and expand efficiency area of target. Also, FTS can prepare the thin film that has a good compositional segregation and spinodal decomposition. Ti [7] as underlayer, CoCrTa as magnetic layer, and an interlayer of Pt and paramagnetic CoCr were deposited on Si substrate. The background pressure was 5×10^{-7} Torr. The substrate temperature fixed at 250°C. Sputtering processing was performed at input current 0.2 A under Ar gas pressure of 1 mTorr. The thickness of magnetic layer and underlayer were 50 nm and 20 nm respectively. To investigate the effect of annealing, postannealing was carried in vacuum of 5×10^{-6} Torr at 100-500°C for 1hour. Magnetic properties were measured by using a vibrating sample magnetometer (VSM), and the crystalline orientation of the film was investigated by X-ray diffractometer. The surface of film was observed by atomic force microscopy (AFM).

DISCUSSION

Figure 1 shows XRD patterns of prepared films on variation of interlayer thickness. Diffraction intensity of Co (002) of CoCrTa/[Pt/Ti] was five times stronger than CoCrTa/[CoCr/Ti] and CoCrTa/Ti. This result suggests that crystalline growth of Pt is well at high temperature and Pt promote crystalline growth of CoCrTa layer deposited on it.

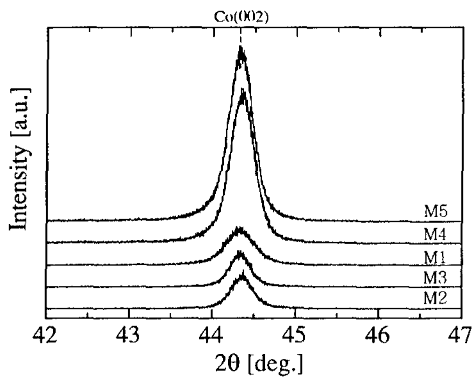


Figure 1. XRD patterns of prepared films on variation of interlayer thickness

Table 1. Perpendicular coercivity $H_{c\perp}$, in-plane coercivity $H_{c//}$ and dispersion of the c-axis orientation $\Delta\theta_{50}$ of prepared thin film.

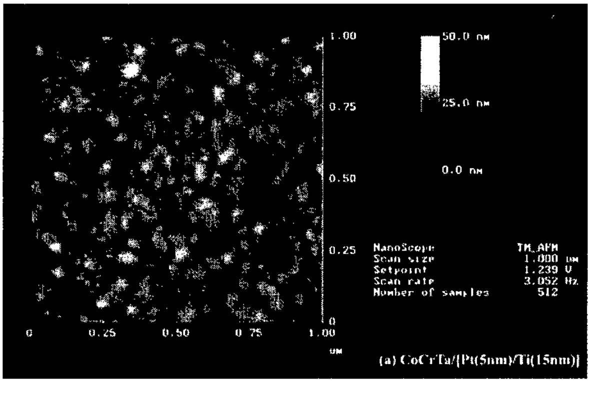
Media	Layer Structure	$H_{c\perp}$ [kOe]	$H_{c//}$ [kOe]	$\Delta\theta_{50}$ [deg.]
M1	CoCrTa/Ti (20)	1.67	0.398	5.69
M2	CoCrTa/[CoCr (10)/Ti (10)]	1.03	0.432	8.62
M3	CoCrTa/[CoCr (5)/Ti (15)]	1.32	0.552	8.28
M4	CoCrTa/[Pt (10)/Ti (10)]	1.91	0.372	3.62
M5	CoCrTa/[Pt (5)/Ti (15)]	1.98	0.344	3.45

* Number of parentheses shows thickness of film

Table 1 shows perpendicular coercivity $H_{c\perp}$, in-plane coercivity $H_{c//}$ and dispersion of the c-axis orientation $\Delta\theta_{50}$ of prepared thin film.

Dispersion of the c-axis orientation $\Delta\theta_{50}$ of CoCr-based thin films with the c-axis perpendicular to the film plane was evaluated from the full width at half maximum o f the rocking curve of Co(002) peak.

$H_{c\perp}$, $H_{c//}$ and $\Delta\theta_{50}$ of prepared thin film with Pt interlayer exhibit a good value compared with that of paramagnetic CoCr layer. This result is due to superior matching between Pt (111) plane and CoCrTa (002) plane than paramagnetic CoCr deposited on Ti underlayer. Figure 2 shows AFM images of CoCrTa/[Pt/Ti] and CoCrTa/[CoCr/Ti] trilayered film at interlayer 5nm thickness. Scan size is 1×1μm. As shown in Figure 2, crystalline grain of magnetic layer of trilayered film with Pt interlayer was explicitly observed than paramagnetic CoCr.



(a) CoCrTa/[Pt(5nm)/Ti(15nm)]

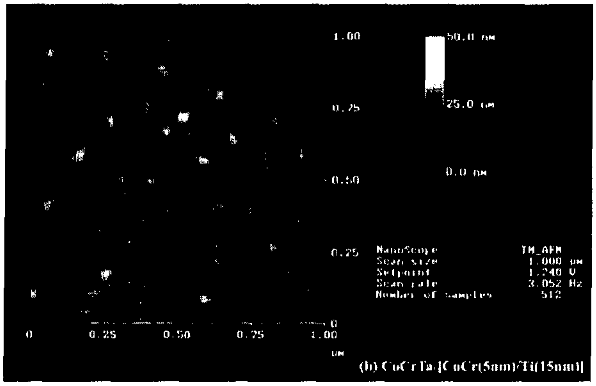


Figure 2. AFM images of (a) CoCrTa[Pt(5nm)/Ti(15nm)] and (b) CoCrTa[CoCr(5nm)/Ti(15nm)] trilayered film(R_a; (a) 1.816nm, (b) 1.274nm).

The effect of crystallographic and magnetic characteristics on varying annealing temperature was investigated. Figure 3 shows XRD patterns of trilayered film with interlayer of Pt on annealing temperature. For all of the prepared samples, it was observed that peak of crystalline plane of CoCrTa was moved at T_a 500°C. The reason for this behavior was exposed due to crystalline size that was affected by distance between planes. Figure 4 shows dependence of $H_{c\perp}$ and $\Delta\theta_{50}$ on annealing temperature. $\Delta\theta_{50}$ slightly decrease with increasing annealing temperature. However, at T_a is above 300°C, $H_{c\perp}$ drops rapidly.

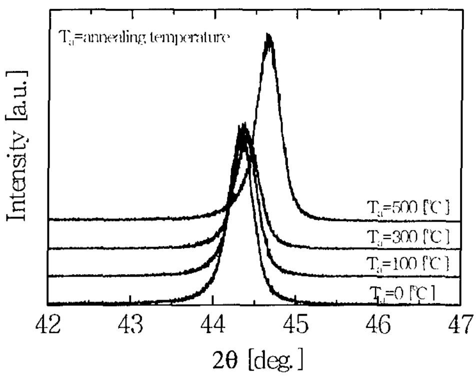


Figure 3. XRD patterns of CoCrTa/[Pt/Ti] trilayered thin film on annealing temperature.

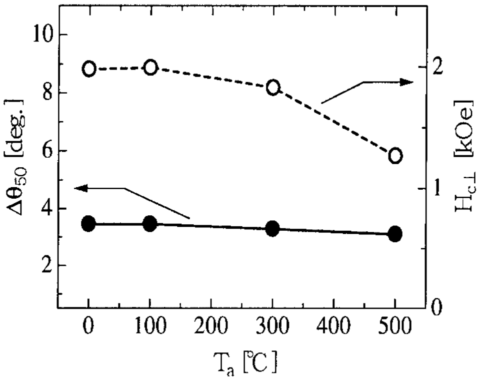


Figure 4. Dependence of $H_{c\perp}$ and $\Delta\theta_{50}$ of CoCrTa/[Pt/Ti] trilayered thin film on annealing temperature.

At first, making Pt element diffusing into Pt element into CoCrTa layer through annealing treatment, this experiment was intending to form CoCrPtTa crystallite with high perpendicular coercivity. However, perpendicular coercivity $H_{c\perp}$ was decreased due to segregation structure of magnetic layer according to homogenized with increasing annealing temperature.

Figure 5 shows AFM images of CoCrTa/[Pt(5nm)/Ti] for as-deposited and postannealed at 500°C. Average crystalline size was 34.02nm and 36.36nm respectively.

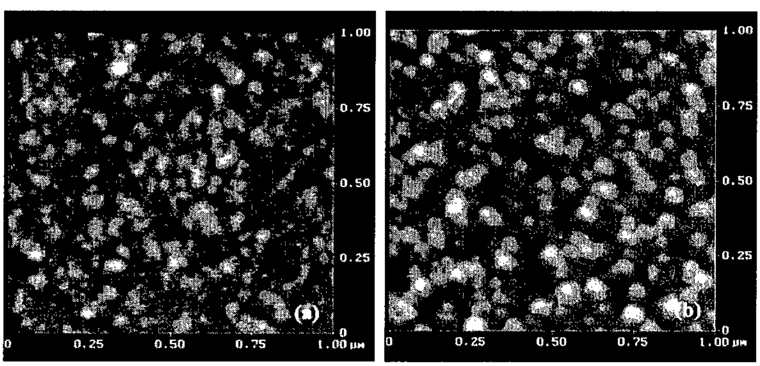


Figure 5. AFM images of as-deposited and postannealed at 500°C of CoCrTa/[Pt(5nm)/Ti] trilayered thin film. (a) as-deposited(R_a=1.816nm) (b) postannealed(500°C)(R_a=2.399nm)

CONCLUSIONS

We prepared CoCr-based trilayered thin film with varying interlayer thickness using the New Facing Targets Sputtering System. As a result, trilayered thin film with Pt interlayer shows good value of perpendicular coercivity and dispersion angle of c-axis compared with the film with CoCr interlayer. Also, trilayered film with 5nm of interlayer thickness had higher perpendicular coercivity $H_{c\perp}$ and had lower dispersion of the c-axis orientation $\Delta\theta_{50}$ than 10nm of interlayer thickness. Especially, trilayered film with Pt interlayer thickness of 5nm exhibited high perpendicular coercivity value about 2kOe and dispersion of the c-axis orientation 3.45°. That means epitaxial growth is achieved due to superior crystalline orientation of Pt and Ti layer at high temperature and matching between CoCrTa magnetic layer and Pt layer deposited on those. So, it was improved crystallographic and magnetic characteristics by inserting interlayer to CoCr-based thin film alloy.

A Crystallographic characteristic of CoCrTa/[Pt/Ti] trilayered film was improved about 3.1° of $\Delta\theta_{50}$ at annealing temperature 500°C. But, for effect of the interference between grain lattice, perpendicular coercivity was decreased.

REFERENCES

1. S.Iwasaki and K.Ouchi, *IEEE Trans. Magn.*, **MAG-14**, 5, 849 (1797)
2. S.Nakagawa, K.Takayama, A.Sato and M.Naoe, *IEEE Trans. Magn.* **35**, 2739 (1999)
3. C.Byun, E.M.Simpson, J.M.Siversen and J.H.Judy, *IEEE Trans. Magn.*, **MAG-21**, 1453 (1985)
4. Y.Nimura, Y.Kitamoto, S.Nakagawa and M.Naoe, *IEEE Trans. Magn.*, **23**, 2464 (1987)
5. K.H.Kim, S.H.Kong, I.H.Son, M.Naoe and S.Nakagawa, *Applied Surface Science*, **169**, 409 (2001)
6. S.Kadokura, M.Naoe, *J. Magn. Magn. Mater.*, **193**, 114 (1999)
7. O.Kitakami, K.Ojima, Y.Ogawa, T.Maro and H.Fujiwara, *IEEE Trans. Magn.*, **MAG-23**, 5, 27197 (1996)